DU MONT

CATHODE-RAY OSCILLOGRAPH
TYPE 164-E

OPERATING INSTRUCTIONS

ALLEN B. DU MONT LABORATORIES, INC.
PASSAIC, NEW JERSEY
U. S. A.

ALLEN B. DU MONT LABORATORIES, Inc.
PASSAIC, N. J., U. S. A.

TYPE 164-E CATHODE-RAY OSCILLOGRAPH, SERIAL NO._____

THIS CARTON CONTAINS THE FOLLOWING:

QUANTITY	DESCRIPTION	CHECK
1	Type 164-E Cathode-Ray Oscillograph—complete with Type 3AP1 Cathode-Ray Tube	✓
1	Calibrated Scale—Type 216-A, Part 27-2	✓
1	Guarantee Notice, Part 33-11	✓
1	Voltage Warning Card 115 V, Part 33-330 230 V, Part 33-329—(Attached to handle)	✓
1	Inspection Tag, Part 33-9—complete (Attached to handle)	✓
1	Warranty Service Folder, Part 33-12 (Enclosed with Operating Instructions)	✓
1	Notice to Customers, Part 33-10	✓
1	Operating Instructions, Part 33-595	✓

NOTICE TO CUSTOMER

If upon receipt and inspection, this instrument fails to conform with the above listing, return this sheet to the factory for adjustment. Please fill in serial number above and note details of defect on reverse side.

Packer N A

DE-242-2
33-619

IMPORTANT
WARRANTY AND SERVICE NOTICE

for

DU MONT CATHODE-RAY TUBES
and DU MONT INSTRUMENTS

ALLEN B. DU MONT LABORATORIES, Inc.
Passaic, N. J., U. S. A.

WARRANTY

DuMont Instruments

All instruments manufactured by Allen B. DuMont Laboratories, Inc., are guaranteed to equal or exceed all specifications for that particular instrument as published by the company. They are further guaranteed against defective materials and workmanship for a period of one year from date of sale, and we will promptly repair the instrument or replace it, at our discretion, at any time within the guarantee period should any defect develop from these causes or the instrument be not as represented, upon our inspection of the equipment.

In order that this guarantee be effective, it is necessary that the enclosed guarantee card be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information should be given, since a record of every instrument is maintained at our office. This record constitutes our source of information when any correspondence is necessary. Both the **type number and the serial number** of the instrument must be given on this card in order that the information be complete.

DuMont Cathode-ray Tubes

All cathode-ray tubes manufactured and sold by Allen B. DuMont Laboratories are guaranteed for a life of 1,000 hours or for six months, depending upon which expires first. The only exceptions to this guarantee are burned-out heaters and broken glass. Cathode-ray tubes will be promptly replaced within the guarantee period if, upon our inspection, the tube has failed within less than its normal expected life.

In order that this guarantee be effective, it is necessary that the enclosed guarantee card be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information should be given in order that the records which we maintain on your particular tube will be accurate. When correspondence is necessary, both **type number and serial number** of the tube should be mentioned. The serial number of DuMont cathode-ray tubes will be found on the glass stem of the electron gun.

SPECIFICATIONS

The right is reserved to change the specifications of any equipment, without notice, at any time. This right shall not incur any liability to Allen B. DuMont Laboratories, Inc., to change equipment previously sold, or to supply new equipment in accordance with earlier specifications.

SERVICE

DuMont equipment is designed and manufactured in accordance with the best practices of modern engineering, and it is fully inspected before it leaves our factory. Under normal operation it may be expected to give long, trouble-free service. In order to insure factory service and proper consideration within the guarantee period, the enclosed guarantee card should be properly filled out and mailed to the factory immediately upon receipt of the equipment.

In many cases, equipment has been returned to us, without authorization, and without any need for our examination, resulting in unnecessary shipping costs. In the event that you feel you have not received satisfactory operation from this equipment, you should immediately contact our Contract Department, mentioning the **type number and serial number,** completely outlining all characteristics of the failure, and describing the method in which the equipment has been used. It is important that such information be given, since much time often can be saved when all operating conditions are known.

When it is found necessary to return cathode-ray tubes or instruments to the factory, written permission should first be obtained from our Contract Department. It may be convenient, at the time of this writing, to outline the application of the equipment as discussed above since, with such information, we often are able to make decisions and suggestions which will avoid returning it to our plant.

All equipment returned to our plant should be shipped, carefully packed, via express prepaid. Cathode-ray tubes larger than three inches screen diameter should be shipped separately and should not be left mounted in their socket within the instrument. In addition, all equipment should be properly identified either by a packing slip or, preferably, by a suitable tag affixed to it. Unidentified equipment which has been returned to us is a serious source of needless errors and delays.

PRINTED IN U.S.A.

ALLEN B. DU MONT LABORATORIES, INC. 138K15-143-3

Operating Instructions

For

DU MONT TYPE 164-E CATHODE-RAY OSCILLOGRAPH

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Passaic, New Jersey, U. S. A.

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ALLEN B. DU MONT LABORATORIES, INC.
Passaic, New Jersey
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DE-243-Issue 5
Part No. 33-595

TYPE 164-E
CATHODE-RAY OSCILLOGRAPH

OPERATING INSTRUCTIONS

GENERAL SPECIFICATIONS

POWER SUPPLY RATINGS

Voltage*	115 or 230 volts a.c.
Frequency	40-60 cycles
Power Consumption	50 watts
Fuse Protection	1 ampere

OPERATING LIMITS

Deflection sensitivity (with maximum amplification)

Vertical	0.80 r.m.s. volts/inch
Horizontal	0.65 r.m.s. volts/inch

Deflection sensitivity direct connection to cathode-ray tube plates	30 r.m.s. volts/inch

Input Characteristics:

Vertical amplifier	1 megohm
Horizontal amplifier	0.8 megohm
Voltage gain, vertical amplifier	43 times
Voltage gain, horizontal amplifier	55 times
Frequency range of amplifiers	5 to 100,000 "sinusoidal" c.p.s.
Frequency range of timing axis	15 to 30,000 "sawtooth" c.p.s.
Max. allowable a.c. voltage input to amplifiers	250 volts
Max. allowable d.c. voltage input to amplifiers	400 volts
D.C. voltage delivered by high voltage section of power supply	1100 volts
D.C. voltage delivered by low voltage section of power supply	415 volts

TUBES AND FUNCTIONS

1—Type 80 Half-wave Rectifier
1—Type 80 Full-wave Rectifier
1—Type 6C6 Vertical Amplifier
1—Type 6C6 Horizontal Amplifier
1—Du Mont Type 2B4 Saw-tooth Oscillator
1—Type 3AP1 or 3AP5 Cathode-ray Tube

PHYSICAL SPECIFICATIONS

Height (Exclusive of handle and feet)	11⅞ inches
Width	7⅜ inches
Depth	14 inches
Weight	20 pounds

* See schematic for transformer connections.

INSTALLATION

The Type 164-E Cathode-ray Oscillograph is shipped ready to operate. All tubes are in place and it is only necessary to plug into a line of the proper frequency and voltage.

CONTROLS

All controls of the Type 164-E Oscillograph are on the front panel and are plainly marked. The following description gives the location and use of the various controls. Because all the controls are on the front panel, it was deemed advisable to distinguish in some manner the controls frequently adjusted from those more permanently set. Hence, the synchronizing, coarse and fine frequency, and the horizontal and vertical amplifier controls have red-bar knobs. In the upper left corner is the intensity control. It controls the intensity of the trace and also carries with it the power switch, the "OFF" position being at the extreme counter-clockwise position. At the upper right is the focus control. Just below the intensity control is the vertical-positioning knob which controls the up and down movement of the spot or trace, while directly below the focus control is the horizontal-positioning knob which controls the left and right movement of the pattern. The synchronizing control is in the center of the panel just below the cathode-ray tube. Directly below the positioning controls are the amplifier gain controls, the vertical being on the left and the horizontal on the right. In the center of the panel under synchronizing is the vernier or fine frequency control of the linear sweep while directly below it is a rotary switch which controls the frequency range in six steps. The approximate range of these steps is as follows:

1—Sweep off.
2—15 to 60 cycles.
3—60 to 220 cycles.
4—220 to 900 cycles.
5—900 to 3,000 cycles.
6—3,000 to 10,000 cycles.
7—10,000 to 30,000 cycles.

At the bottom of the panel on the left side is a switch which permits either internal or external synchronizing while on the right, a switch places the horizontal amplifier in operation with the sweep, or connects it to the horizontal terminal post for external use.

The controls are arranged so that the minimum setting is obtained when the knobs are turned counter-clockwise and maximum when turned clockwise.

TERMINALS

The vertical input terminal posts are located on the left side of the panel, the lower post of the pair being the ground. The horizontal input is to the right and as in the previous pair the bottom post is the ground.

On the back of the instrument is a plate with five screw-type terminals. These permit disconnecting of either or both amplifier circuits, allowing a direct connection to the deflection plates. This feature will be found a great convenience in working with d. c. or high frequency applications. The location of circuits on the back panel will be found on page 9 of this manual.

CAUTIONS AND WARNINGS

1. Do not operate this unit with the case removed, since high voltages are employed.

2. Do not experiment with magnets around or near the case of the oscillograph. You may impair or render your oscillograph useless.

3. Do not place the unit over, under, or near a power transformer or reactance carrying a. c., as the field set up will cause distortion of the patterns to an extent that will make conclusions impossible.

4. Do not allow a small line or spot of high brilliancy to remain stationary on the screen for any length of time as the screen may become burned or discolored.

INSTRUCTIONS FOR USE OF THE OSCILLOGRAPH

This procedure is included to acquaint the operator with the operation of the oscillograph. It is suggested that the operator follow these instructions and familiarize himself with the controls and their locations before attempting any use or measurement.

Turn the two positioning controls, the focus, the synchronizing and the horizontal gain control to the halfway point. Then turn the synchronizing switch to internal and the horizontal switch to the sweep position. Place the frequency control switch on position No. 2 and turn off the vertical amplifier. Connect the power cord to a suitable a. c. source and turn the intensity control clockwise until a horizontal line appears. Now adjust both the intensity and focus controls until a sharp, clear cut line is secured. Do not use greater brilliance than necessary to get a satisfactory visible trace. This trace can now be positioned to the center of the screen, and if a small source of a. c. is connected to the vertical posts a pattern will form on the screen as the vertical amplifier control is advanced. This signal may be obtained by connecting a wire from the a-c test signal terminal post to the vertical input terminal post. If one wave is secured it indicates that the sweep is of the same frequency as the signal applied; or if two waves appear, the sweep is at one-half the frequency of the applied signal, and so on. The pattern can be caused to stand still or drift, by turning the synchronizing control. In some cases distortion can be caused by over-synchronizing, so use only enough to lock the pattern.

It is general practice to use several waves when examining wave forms, especially on frequencies above 1000 cycles.

While the pattern given by an oscillograph shows peak voltages, it is a simple matter for the operator to acquaint himself with the deflection in inches secured at various settings of the gain control with r. m. s. (meter readings) voltages applied. If considerable use is made of this feature it may be advisable to plot a curve of the voltages required to give a certain deflection.

As this instruction book is intended for the radio service man, it will not include miscellaneous applications, lissajou figures, photography, etc. We suggest that the service man acquaint himself with the theory and use of the instrument by studying in his spare time. The following texts will be of value: "The Cathode-Ray Tube at Work," by John Rider, and "The Cathode-Ray Oscillograph in Radio Research," by R. A. Watson Watt.

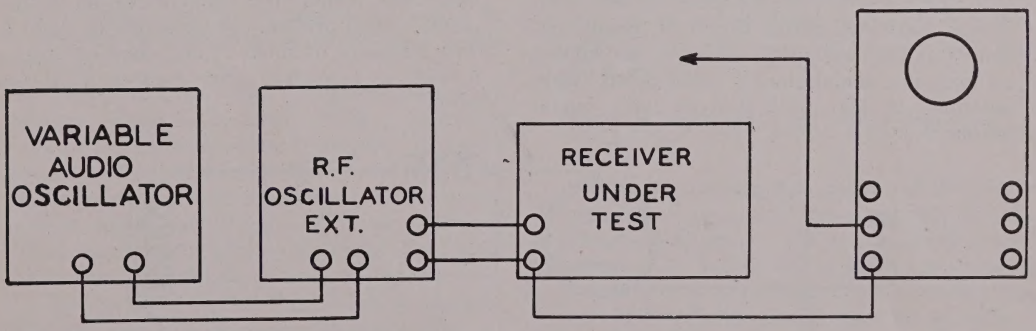


Fig. 1

VISUAL ALIGNMENT OF RADIO SETS

This was the first and simplest method of alignment and the oscillograph merely took the place of the outer meter. It consisted of using a signal generator with some form of audio modulation which was applied to the receiver and the audio output was measured with an oscillograph. Unlike its predecessor, the output meter, it not only shows the voltage output but also the shape of the wave, and enables the study of the detector and audio systems permitting the location of audio distortion, overloading, etc. While this method was not the most efficient and has now been supplanted by the modern frequency modulated oscillator of constant band width, which is undoubtedly better for pure alignment work, it is coming again to the fore, this time under the title of overall frequency response.

In this case the old type audio oscillator is replaced by an adjustable, or beat type, oscillator capable of producing essentially sine waves of the same voltage output, from five cycles to fifteen thousand cycles. It is apparent that this setup will determine where the response of a receiver starts to fall off at either the high or low frequencies. Moving from the detector to the audio system and repeating the readings will show whether further loss is suffered.

VISUAL RESONANCE CURVES

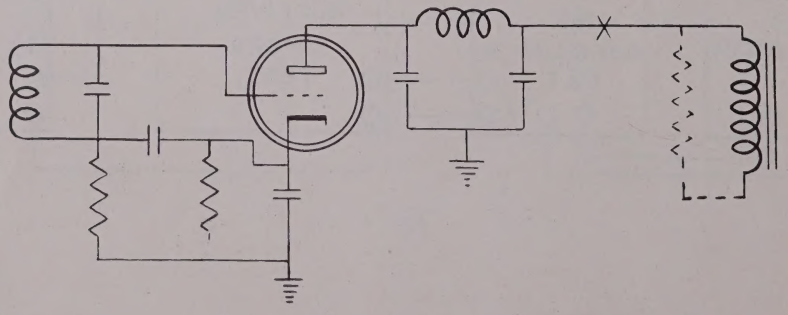
The general proceduce involved is as follows: An R. F. oscillator is provided with some means that will serve to vary its frequency a few kilocycles either side of the frequency to which it is tuned. In the older units it consisted of a motor driven vernier variable condenser, connected across the main tuning condenser of the oscillator. This process, known as frequency modulation, is often called "wobbulation" to distinguish it from audio modulation.

For IF alignment these old systems are nearly as good as the latest types, but a little thought will disclose the fact that the width of the band swept will be determined by the capacitance of the main condenser, so the trend has been toward beat-frequency oscillators which produce a constant band width.

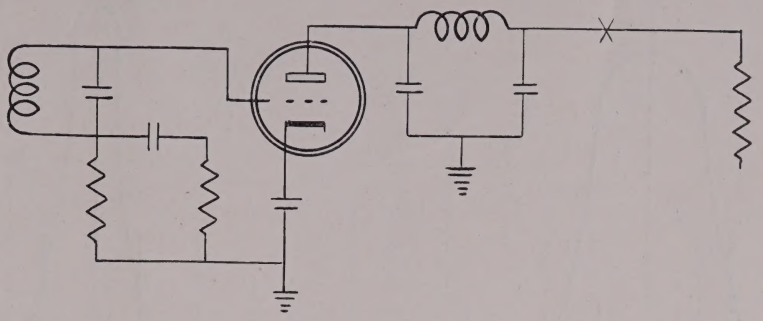
There are numerous methods for producing a frequency-modulated signal. It can be effected by a motor-driven condenser, a motor-driven disc, vibrating reed, or by electronic means, and, as previously stated, may or may not include the features of constant band width. However, regardless of the method, the principle of operation is the same. The output of the generator in frequency plotted against time will appear as a pyramid for the 360 degrees of frequency modulation. If the sweep is adjusted to twice this frequency of rotation, the spot will sweep a second time while the oscillator frequency goes from maximum to minimum. Thus, during 180 degrees of the frequency-modulation cycle the oscillator frequency sweeps from minimum to maximum, passing through the resonant point of the circuit tested and tracing the resonance curve on the screen. During the next 180 degrees, the frequency goes from maximum to minimum and a second curve is traced. If the resonance curve of the circuit is symmetrical, the two traces can be made to coincide.

In taking resonance curves it is advisable to take the A. V. C. action off the stage or stages being tuned. Intermediate-frequency stages should always be tuned to peak at the frequency for which the set is designed.

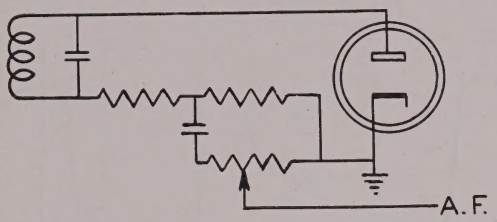
In connecting the oscillograph to the set under test, if there is a reactive load on the detector, it will probably be advisable to shunt it with a resistor of about 25,000 ohms or replace it with a 1,000,000 ohm resistor as shown below.



In cases of resistive load this connection can be made as follows:



In cases of diode connection across the diode load:



In general the ground circuit of the oscillograph is connected to the ground of the receiver and the deflection plate to the point X in the drawings. It should be noted that in a.c.—d.c. (transformer-less) receivers, the chassis is usually connected to one side of the power line. Most receiver manufacturers give complete directions for connection to oscillographs in their service sheets; therefore, it would be confusing to attempt to cover all cases in this manual.

There may be cases where symmetry of curves cannot be secured. This is generally due to regeneration in the IF stages. It should be considered as an indication of trouble. The most common source is common coupling in the power supply due to too small or open bypass condensers. Of course, capacity coupling, poor shielding, etc., can cause the same effect.

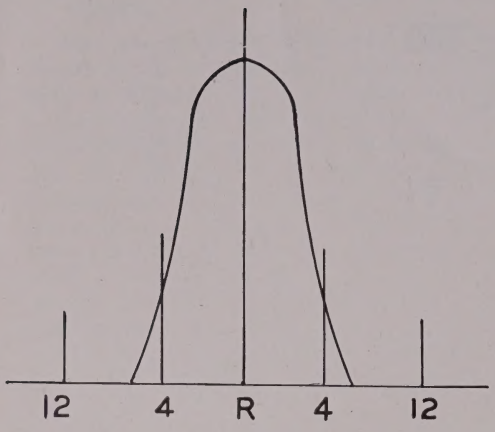
The curves shown on Page 8 are to acquaint the operator with their general appearance.

HUM MEASUREMENTS

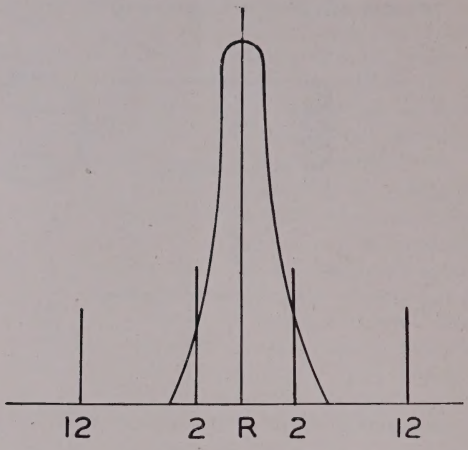
The sweep can be set to 60 cycles and the pattern locked, by using external synchronization with 60 cycles obtained by connecting the external synchronizing terminal post to the a-c test signal post and throwing the synchronization selector switch to the external position. A test probe then can be used for checking the entire circuit, the magnitude of the hum being indicated by the amplitude of the waves. This enables checking of the various points of the filter circuit, and the effect of changes in chokes, condensers or alignment of parts is readily seen and compared.

OSCILLATION AND REGENERATION

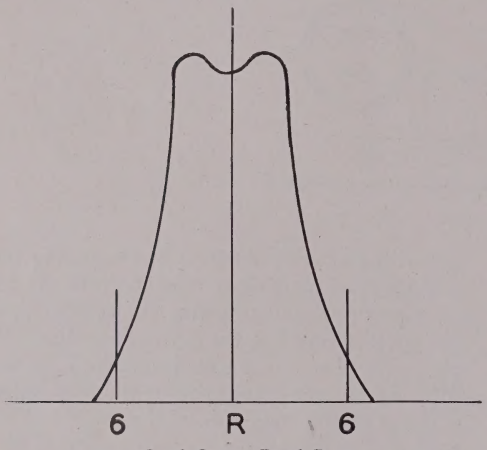
With the oscillograph connected across the suspected circuit and no signal applied, only the straight horizontal trace of the sweep should appear. Oscillation will appear as a widening of the sweep trace. Regeneration which is just short of oscillation can be seen by applying a radio signal modulated by an audio oscillator of good wave form. You will become familiar with the shape of this wave and since regeneration causes serious distortion, its presence will be readily apparent.



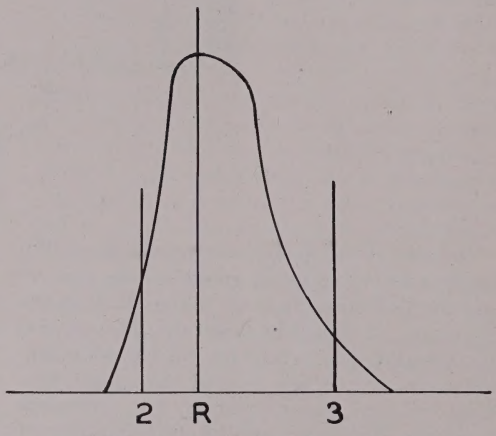
Good Curve, Average Receiver



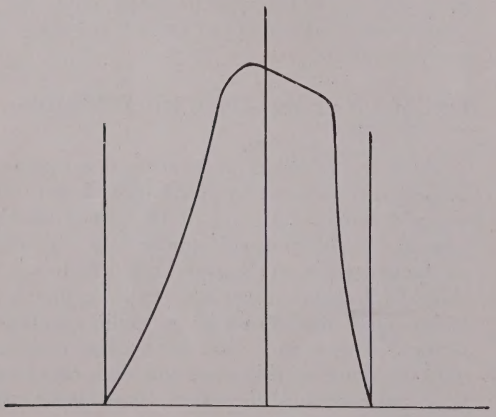
Good Curve, Old Receiver
Narrow Response



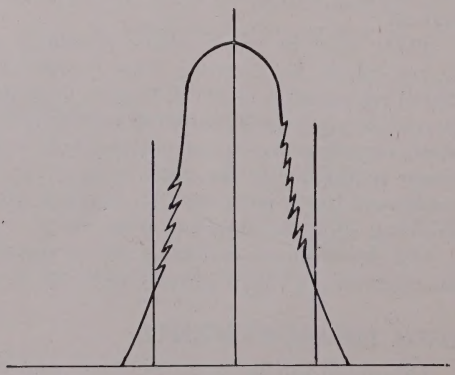
Good Curve, Band Pass



Misaligned Stage Cutoff One Side



Misaligned Band Pass Stage
Cut Off on One Side



Oscillation Generally
Indicated by Jagged Slope

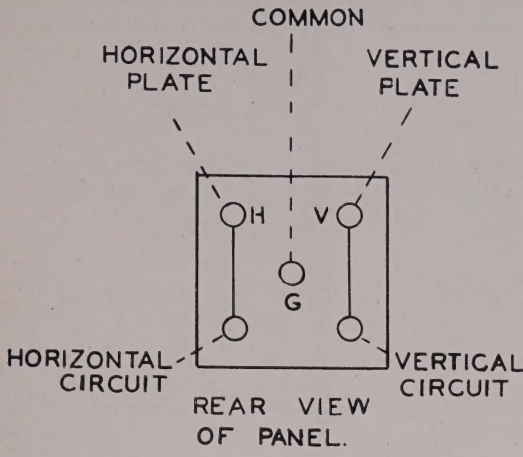


FIG. 2

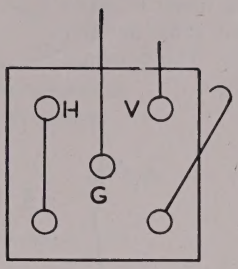


FIG. 3

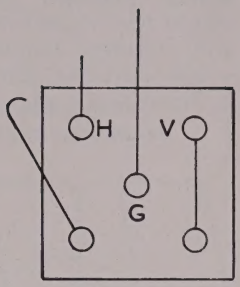
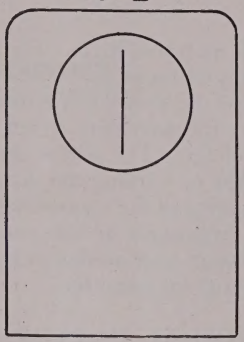
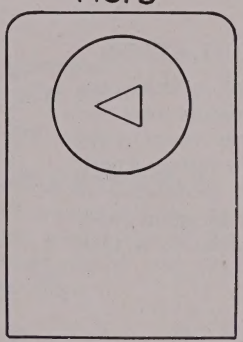
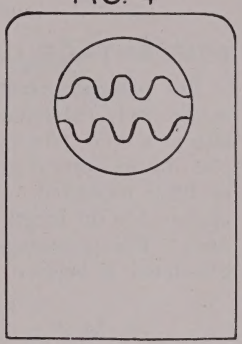


FIG. 4







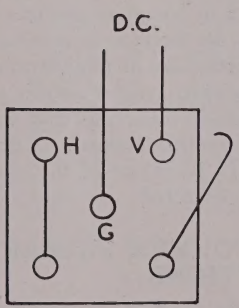


FIG. 5

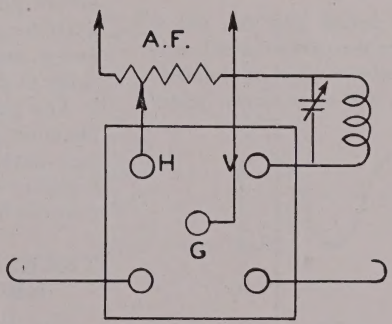


FIG. 6

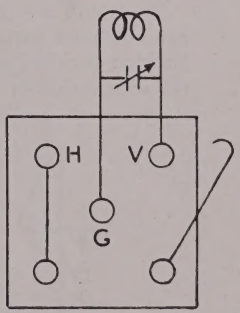


FIG. 7

Methods of Connecting Signals Directly to Horizontal and Vertical Deflection Plates

AUTO RADIO VIBRATORS

The vertical input can be connected in several ways, directly across the contacts or between the center tap and either end of the high voltage windings. Internal synchronization should be used and the waves made to stand still. Incorrect adjustments will cause peculiar rough patterns of many shapes. The drawings in Figure 8 give the general idea.

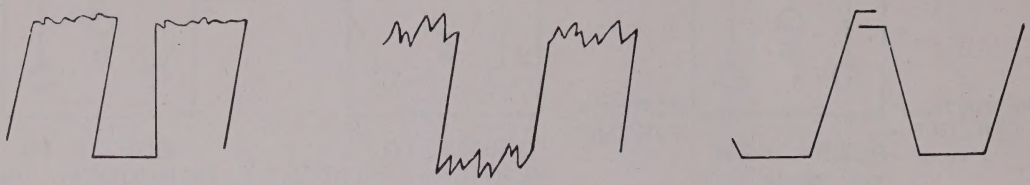


Fig. 8

PERCENTAGE OF MODULATION

The principle of this kind of measurement can be easily understood if we consider only one step at a time. An unmodulated carrier is applied to the vertical plates and a certain length of trace measured. Then the modulation is applied and the length of the trace again measured. The percentage of modulation is then calculated as below:

$$\% \text{ Mod.} = \frac{Lm - Lu}{Lu} \times 100$$

When Lm = Length modulated
Lu = Length unmodulated

Now add the sweep action and you get a band or block pattern for the carrier which will be what is called an envelope when modulated, the appearance of which will be as shown below in Figure 9.

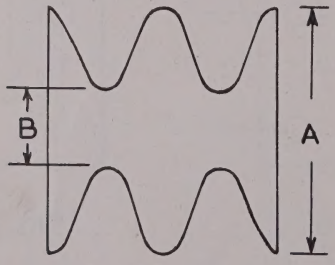


Fig. 9

It is apparent that the sweep has merely allowed the visualizing of the wave form and no change in the formula is effected. We would merely substitute the new terms A and B and get

$$\% \text{ Mod.} = \frac{A - B}{A + B} \times 100$$

It is apparent that if sufficient voltage is available this could be applied to received signals as well as transmitters. On a transmitter it will usually be found that a few turns of wire connected to the vertical deflection plates and placed near the final tank circuit will pick up sufficient voltage. The size of the pattern will be controlled by varying the distance between the pickup coil and the transmitter. In case of very high frequencies or low power it may be found necessary to tune this pickup coil to the frequency of the transmitter.

TRAPEZOIDAL PATTERNS

The trapezoidal pattern is considered better than the modulated envelope pattern for transmitter adjustment. This is because it lends itself better to complete analysis of the transmitter and not because it is better as an indicator of percentage of modulation.

The published articles on this particular application are so numerous that we will not go into detail in this manual. The drawings in Figue 10 are indicative of the type of patterns that can be expected.

TRANSFORMER PRIMARY CONNECTIONS

The Type 164-E Cathode-ray Oscillograph, as supplied, is connected, unless otherwise noted, for use on 115 volts, 60 cycle power lines. Should it become desirable to operate this instrument on 230 volt power lines the primary connections should be changed as shown on the schematic circuit diagram.

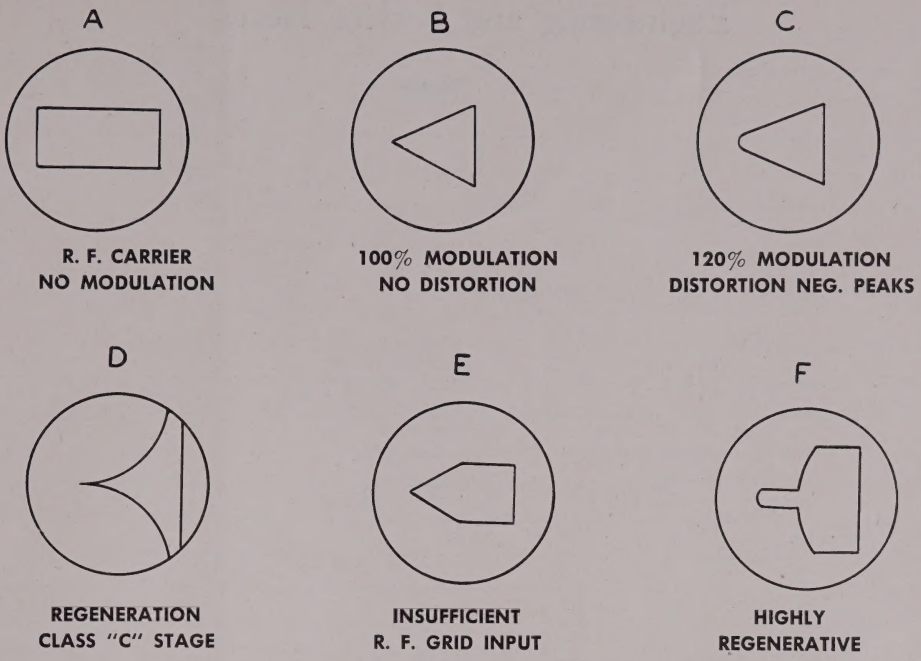


Fig. 10

RETURN TO FACTORY

If you desire to return the unit for repair or inspection, permission should first be obtained from our service department and shipment made as directed by them.

PATENT NOTICE

Manufactured under one or more of the following U. S. Patents:

1,844,117	1,960,333	1,999,407	2,000,014	2,014,106
2,067,382	2,082,327	2,085,576	2,087,280	2,098,231
2,153,800	2,157,749	2,162,009	2,163,256	2,164,176
2,185,705	2,186,634	2,186,635	2,190,020	RE. 21,326
2,201,309	2,207,048	2,208,254	2,209,507	2,221,398
2,225,099	2,227,822	2,229,556	2,245,409	2,245,428
2,249,942	2,249,943	2,269,115	2,269,129	2,280,700
2,280,738	2,290,592	2,297,742	2,297,752	2,299,471
2,299,510	2,315,848	2,319,691	2,321,149	2,328,259
2,331,401	2,337,980	2,338,336	2,338,646	2,343,630
2,345,549	2,346,509	2,347,933	2,355,363	2,356,733
2,364,687	2,365,476	2,372,455	2,372,901	2,373,114
2,379,488	2,384,931	2,389,025	2,391,082	2,391,090
2,391,273		Other Patents Pending		

ALLEN B. DU MONT LABORATORIES, INC.
PASSAIC, N. J., U. S. A.

Engineering and Service Notes

Date	Notes

COMPONENT PARTS LIST

C1—0.5 μf. 1500 volts
C2—0.5 μf. 600 volts
C3—8 μf. 150 volts elec.
C4-C5—4+4 μf. 475 volts elec.
C6—0.05 μf. 400 volts
C7—0.05 μf. 400 volts
C8—0.25 μf. 400 volts
C9—0.25 μf. 400 volts
C10—0.25 μf. 400 volts
C11—0.25 μf. 400 volts
C12—0.05 μf. 400 volts
C13—0.2 μf. 400 volts
C14—0.04 μf. 400 volts
C15—0.01 μf. 400 volts
C16—2500 μμf. 500 volts
C17—600 μμf. 500 volts
C18—125 μμf. 500 volts
C19—50 μμf. 1200 volts
C20—25 μf. 50 volts elec.
C21—0.004 μf. 500 volts
C22—0.004 μf. 500 volts
C23—0.1 μf. 1000 volts
C24—0.1 μf. 1600 volts

L1—8 h. 0.035 amp.
L2—60 mh peaking coil
L3—60 mh peaking coil

F1—1 amp. fuse

V1—3AP1 or 3AP5
V2—6C6
V3—6C6
V4—2B4
V5—80
V6—80

R1—200 K ½ watt
R2—500 K ½ watt
R3—4 meg. ½ watt*
R4—4 meg. ½ watt*
R5—1 meg. ½ watt
R6—4 meg. ½ watt*
R7—4 meg. ½ watt*
R8—15 K ½ watt
R9—100 K ½ watt ± 10%
R10—620 K 1 watt ± 10%
R11—360 K 1 watt ± 10%
R12—850 ohm ½ watt ± 10%
R13—10 K 3 watt ± 10%
R13A—10 K 3 watt ± 10%
R14—25 K 10 watt ± 5%
R15—5 meg. ½ watt ± 10%
R16—5 meg. ½ watt ± 10%
R17—91 K 1 watt ± 5%
R18—1 meg. ½ watt ± 10%
R19—500 K ½ watt ± 10%
R20—850 ohm ½ watt ± 10%
R21—91 K 1 watt ± 5%
R22—1 meg. ½ watt ± 10%
R23—100 K ½ watt ± 10%
R24—1 K ½ watt ± 10%
R25—100 K 3 watt ± 10%
R26—500 K 1 watt ± 10%
R27—10 K ½ watt ± 10%

T1—Power Transformer Part No. 20-6

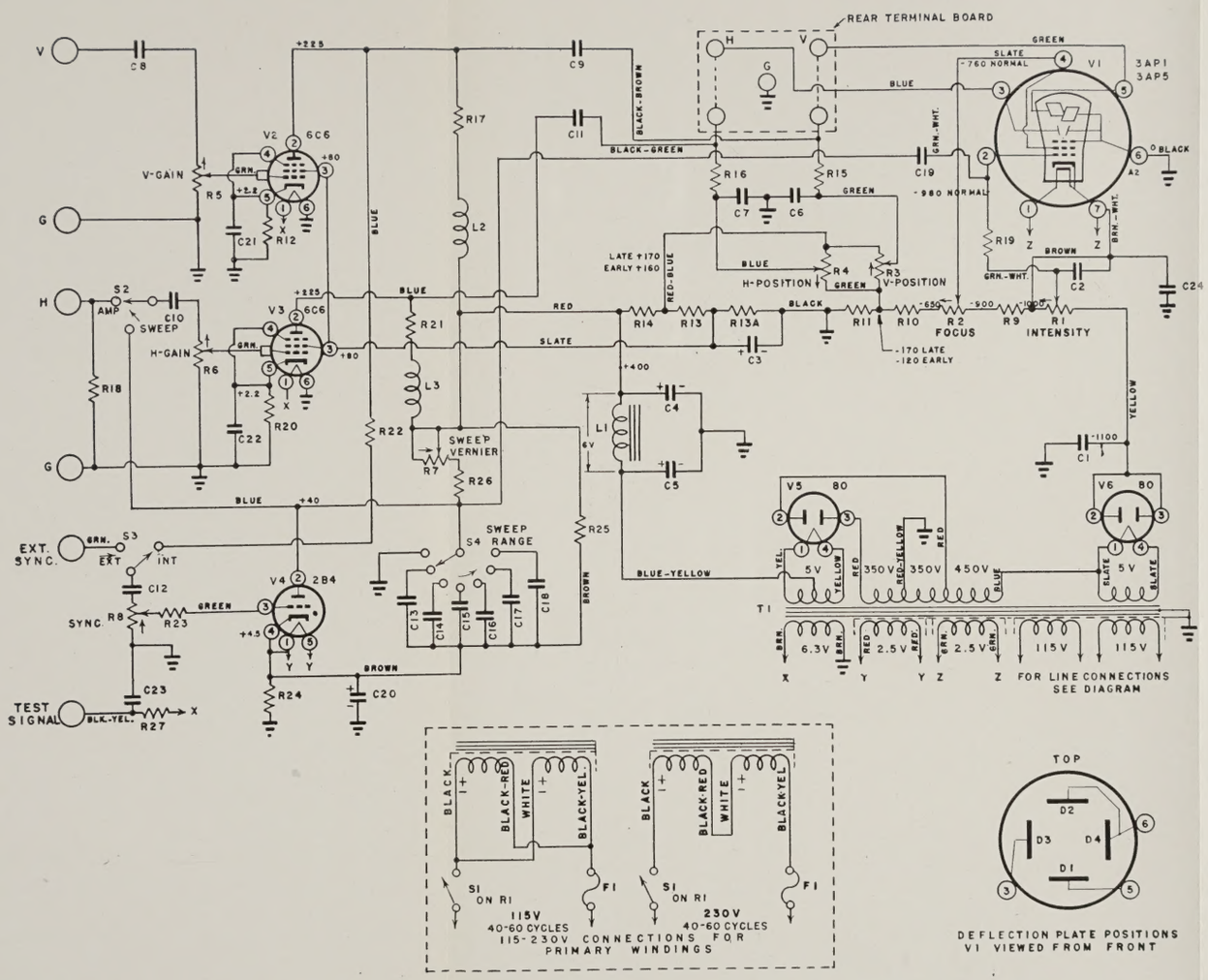
S1—SPST Switch on R1
S2—SPDT Rotary Switch
S3—SPDT Rotary Switch
S4—SP7T Rotary Switch

*These items have been changed for the following:
R3—4 meg. 2 watt
R4—4 meg. 2 watt
R6—4 meg. 2 watt
R7—4 meg. 2 watt

Tolerances given herein are maximum.
Closer tolerance parts may be substituted.

Engineering and Service Notes

Date	Notes



NOTE:
TEST VOLTAGES MAY VARY ± 10 % FROM VALUES GIVEN

SCHEMATIC OF CIRCUIT
TYPE 164-E
CATHODE-RAY OSCILLOGRAPH
Reference DD-4368-C-3

COMPONENT PARTS LIST

C1—0.5 μf. 1500 volts
C2—0.5 μf. 600 volts
C3—8 μf. 150 volts elec.
C4-C5—4+4 μf. 475 volts elec.
C6—0.05 μf. 400 volts
C7—0.05 μf. 400 volts
C8—0.25 μf. 400 volts
C9—0.25 μf. 400 volts
C10—0.25 μf. 400 volts
C11—0.25 μf. 400 volts
C12—0.05 μf. 400 volts
C13—0.2 μf. 400 volts
C14—0.04 μf. 400 volts
C15—0.01 μf. 400 volts
C16—2500 μμf. 500 volts
C17—600 μμf. 500 volts
C18—125 μμf. 500 volts
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C22—0.004 μf. 500 volts
C23—0.1 μf. 1000 volts
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L1—8 h. 0.035 amp.
L2—60 mh peaking coil
L3—60 mh peaking coil

F1—1 amp. fuse

V1—3AP1 or 3AP5
V2—6C6
V3—6C6
V4—2B4
V5—80
V6—80

R1—200 K ½ watt
R2—500 K ½ watt
R3—4 meg. ½ watt*
R4—4 meg. ½ watt*
R5—1 meg. ½ watt
R6—4 meg. ½ watt*
R7—4 meg. ½ watt*
R8—15 K ½ watt
R9—100 K ½ watt ± 10%
R10—620 K 1 watt ± 10%
R11—360 K 1 watt ± 10%
R12—850 ohm ½ watt ± 10%
R13—10 K 3 watt ± 10%
R13A—10 K 3 watt ± 10%
R14—25 K 10 watt ± 5%
R15—5 meg. ½ watt ± 10%
R16—5 meg. ½ watt ± 10%
R17—91 K 1 watt ± 5%
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